BY NEIL SWIDEY

WHAT IF THE LIGHTS GO OUT?

→ IN OUR WIRED SOCIETY, SURVIVING EVEN A DAY WITHOUT ELECTRICITY CAN BE A HARDSHIP (JUST ASK THE NEARLY 2 MILLION OF US WHO LOST IT LAST OCTOBER). BUT THANKS TO THE COMBINATION OF FREAK STORMS AND A GROANING GRID, DARKER DAYS MAY STILL BE AHEAD.

A couple of minutes past 8 p.m., five days after the Halloween storm had blacked out much of Boxborough, Maureen Strapko ushered out the last patron from the town library and locked the doors for the night. While most of that northwest-of-Boston community – like much of the region – remained in the dark, the Sargent Memorial Library had been welcoming the biggest crowds of Strapko's decade-long tenure. That's mainly because restoring power to key town facilities like the fire and police departments had also turned it back on at the nearby library.

Across the week, the place had become a refuge for weary residents needing to warm up, use the bathroom, and recharge their laptop batteries. Strapko had come to know the precise location of each of the library's 48 electrical outlets in the public areas and had even granted needy patrons access to the outlets in the staff areas. Since the storm, she had opened the library early and closed it late, seeing the protracted power outage as an opportunity to put into action her

belief that libraries should be vibrant community centers, not morgues where people are ssshhhh'd into submission.

In truth, there was another reason Strapko was so willing to put in the extra hours. She had no interest in going home. Her house in neighboring Bolton was also without power, and when there – with no electricity, no heat or hot water, no working refrigerator, no Internet and no phone – she and her husband were left feeling isolated and irritable. She knew the helplessness that nearly 2 million New Englanders were experiencing: the frustration of being ignored or strung along by their electric company; the impulse to clear out of town and cash in every accumulated Marriott rewards point at whichever highway-ramp Courtyard still had a vacant room.

After locking the library doors, Strapko found her husband waiting for her in his car. They headed out of town to a well-lit restaurant for an unhurried supper of hot soup. When they returned to the library to retrieve her car, it was about 10 o'clock. Strapko was astonished to see that there were still half a dozen cars, sport utility vehicles and Prius alike, idling in the parking lot, the drivers' faces lit by the bluish glow of their laptop and smartphone screens. She later learned that all week long, people had been lingering in the parking lot into the early hours of the morning, unwilling to disconnect from the library's 24-hour Wi-Fi lifeline. A dozen years into the new century, this is how hopelessly reliant we've all become on power.

The wreckage from the October 29, 2011, nor'easter was so severe that a host of towns from Lexington to Sturbridge actually canceled Halloween, a notion so preposterous that it was the punch line to a joke Frank Sinatra would toss out during his boozy 1960s Vegas act with the Count Basie Orchestra. ("Mr. Basie and I ran into a string of baaaaad luck. We invested a bundle in a pumpkin farm and then they called off Halloween.") In the days to come, restaurants and markets lost their inventories of perishable food, people stranded in their homes by downed limbs and lines were forced to bundle up in blankets and conduct their lives by flashlight, and patients reliant on electricity for their medical devices were forced to scramble for backup sources of power. Strapko says one mother showed up at the Boxborough library desperate to charge a machine she needed to feed her infant.

We were told the freak storm produced an outlier of an outage. And to an extent that was true: The heavy snow that landed on leaf-dense trees turned the pre-winter blast into a "black swan," something for which it was nearly impossible to prepare. But what if last fall's massive, lingering outage turns out to be less of a black swan and more of the proverbial canary in the coal mine – the harbinger of a dimmer future for us all? The deeper I've delved into the state of the power grid, the more reasons I've found for concern.

In much of the developing world, even in large cities, people expect that at some point during the day, the power will cut out, no matter your location or your station in life. Sue Tierney, one of the nation's leading energy analysts, recalls a trip to India she made in the 1990s while serving as US assistant secretary of energy. She was part of a delegation meeting with India's energy minister, in a government office, when the lights went out. There was some uncomfortable laughter and then a few apologetic comments from ministry officials about how this kind of stuff happens all the time.

Yet here in this country, we've come to expect that whenever we flip the switch or plug in to the outlet, the juice will be there. The power grid has been so reliable over the years that most of us can count on one hand the number of times in our lives when we've been without electricity for any significant stretch. In 1985, when I was in high school, Hurricane Gloria left our street without power for nearly two weeks, long after it had been restored to the rest of Somerset, my Southeastern Massachusetts hometown. For years after that, some of the pencils in our house served as a reminder of the time when my siblings and I had been forced to do homework by candlelight and chose to relieve our boredom by tattooing all those No. 2s with scorch marks.

The last widespread outage in the Northeast, the great blackout of August 2003, showed how intimately interconnected and alarmingly fragile our power grid is. How else to explain the way a problem starting in northeastern Ohio quickly cascaded into a blackout affecting 50 million people across the northeastern United States and parts of Canada? How quickly? Between the moment a power surge came rushing out of Ohio and the moment Manhattan began to go dark, exactly 10 seconds had passed.

LIKE UNFIT PARENTS, WE DON'T PAY ATTENTION TO POWER EXCEPT WHEN IT ANNOYS US.

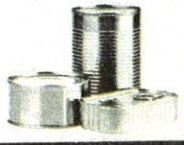
In our relationship to electrical power, we're like one of those unfit parents you see yelling at their kids in line at McDonald's. We don't pay attention to power except when it annoys us – think of an outage as a 5-year-old whining for a different Happy Meal toy – then we scream and vent and say things we probably shouldn't. But rather than investing the time and resources to build a better relationship, we return to ignoring things until the next flare-up. And the utility companies often take advantage of their state of mostly low scrutiny. That's why you never hear much about the $8 million payday for the guy who runs NStar.

Electrical power may rule our economy, but the guts of how it is generated and delivered can be deathly dull. Seriously, have you ever actually tried to *read* your electric bill? The subject can serve as a sedative even to the professionals. At a Department of Public Utilities hearing I attended in Maynard, held so customers could critique the power companies' Halloween-storm performance, I watched from the audience as a DPU engineer sitting on the dais valiantly fought, but ultimately lost, his own battle to stay awake.

But we'd better all begin paying more attention. The grid, for a host of reasons, may be ill-equipped to meet all the enormous

A PREPAREDNESS SHOPPING LIST The US Department of Homeland Security recommends every home have, at the bare minimum, these supplies:

Water (1 gallon per person per day)



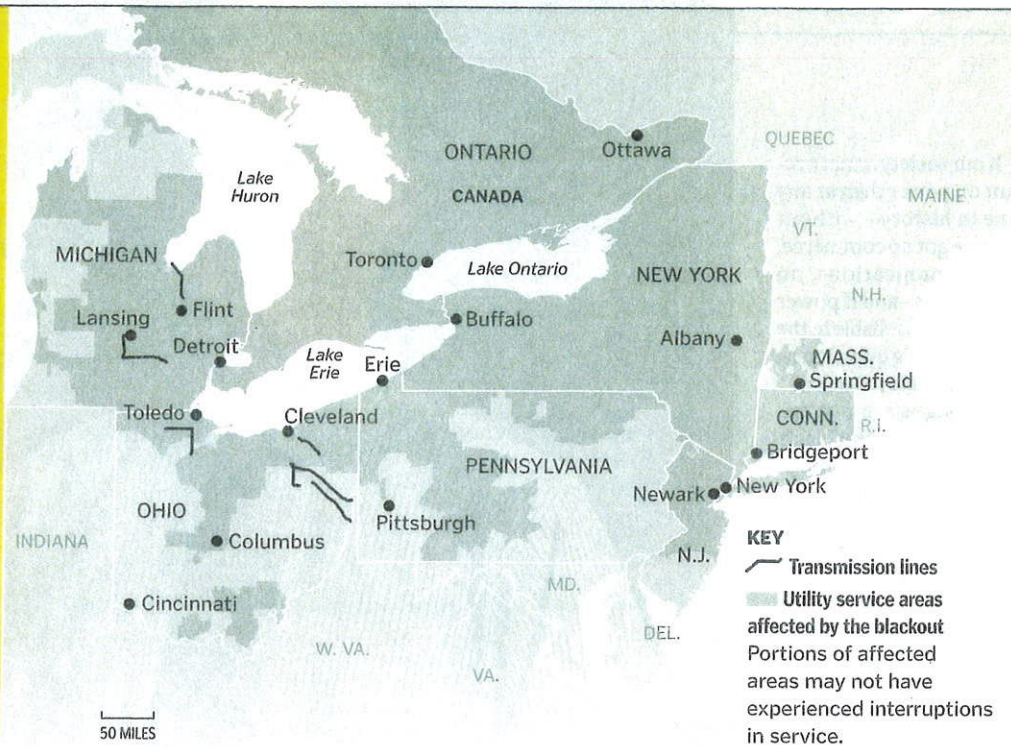
Nonperishable food for three days

Can opener

Battery-powered weather radio with tone alert

ANATOMY OF A BLACKOUT: AUGUST 14, 2003

Just how interconnected is our grid? Interconnected enough that the largest blackout in North America's history – one that left 50 million people without power – could essentially start when a single tree branch touches a single power line.



3:05 PM › In northeastern Ohio, a line carrying 345,000 volts touches a tree limb the utility company had neglected to trim. After a flash of sparks, safety equipment automatically kills the electricity.

3:39 › The first of 16 high-voltage lines in the Akron area trips. Since electricity can't be turned off like water from a spigot, lines overheat, sag, then hit more branches and trip.

4:05:57 › The Sammis-Star high-voltage line outside Cleveland shuts down. This is, a later report explains, the "last point at which a cascade of line trips could have been averted."

4:07:00 › Four of the five Handsome Lake turbines in Western Pennsylvania go offline. Within the next several minutes, more than 500 generating units in the United States and Canada, including at 10 nuclear facilities, shut down.

4:10:37 › Four units at a power plant near Detroit go off. When a subsequent run on gas leaves some stations dry, Michigan's governor signs an order rushing nearly a million gallons of fuel into the area.

4:10:38 › A huge power surge sweeps across Pennsylvania, New Jersey, and New York, through Ontario, and into Michigan. As the blackout grows, the Air Force scrambles jets, in case the blackout is part of a terrorist attack.

4:10:46 › When Cleveland's electricity shuts down, so do the pumps supplying 1.5 million people with drinking water from Lake Erie. The mayor declares a state of emergency and calls in the National Guard to help.

4:10:48 › As power drops in New York and New Jersey, subway and commuter trains stop dead. One spends nearly two stifling hours beneath the East River. Traffic jams grow dozens of miles long.

4:10:54 › The last of more than a dozen lines connecting New York to New England trips, creating a surge that threatens part of Vermont. Amtrak rolls to a stop, stranding as many as 18,000 people. At Six Flags in Agawam, a roller coaster freezes mid-ride and passengers need to be walked off.

4:12 When the cascade finally ripples to a close, 50 million people are without power. Although most will see it restored within hours, parts of Manhattan remain dark for days and Ontario has a week of rolling blackouts. The price tag? An estimated $10 billion.

– *Saumya Vaishampayan*

challenges it faces. For so long, the market for doomsday scenarios of powerlessness has been cornered by survivalists prattling on about Mayan calendars and end of days. Rest assured that these are not my people. In my basement, you won't find 6,000 rounds of ammo or floor-to-rafters stacks of MREs. My level of preparedness tops out at 4 gallons of bottled water, a 6-volt flashlight, and a four-pack of Bumblebee tuna, and each of those items is actually a holdover from last summer, when I briefly succumbed to the pre-Hurricane Irene frenzy.

Still, knowing what I know now, I will be fortifying my family's skimpy emergency supply. The record sales posted last year by a leading manufacturer of residential generators suggests I will have plenty of company.


Batteries


Flashlight

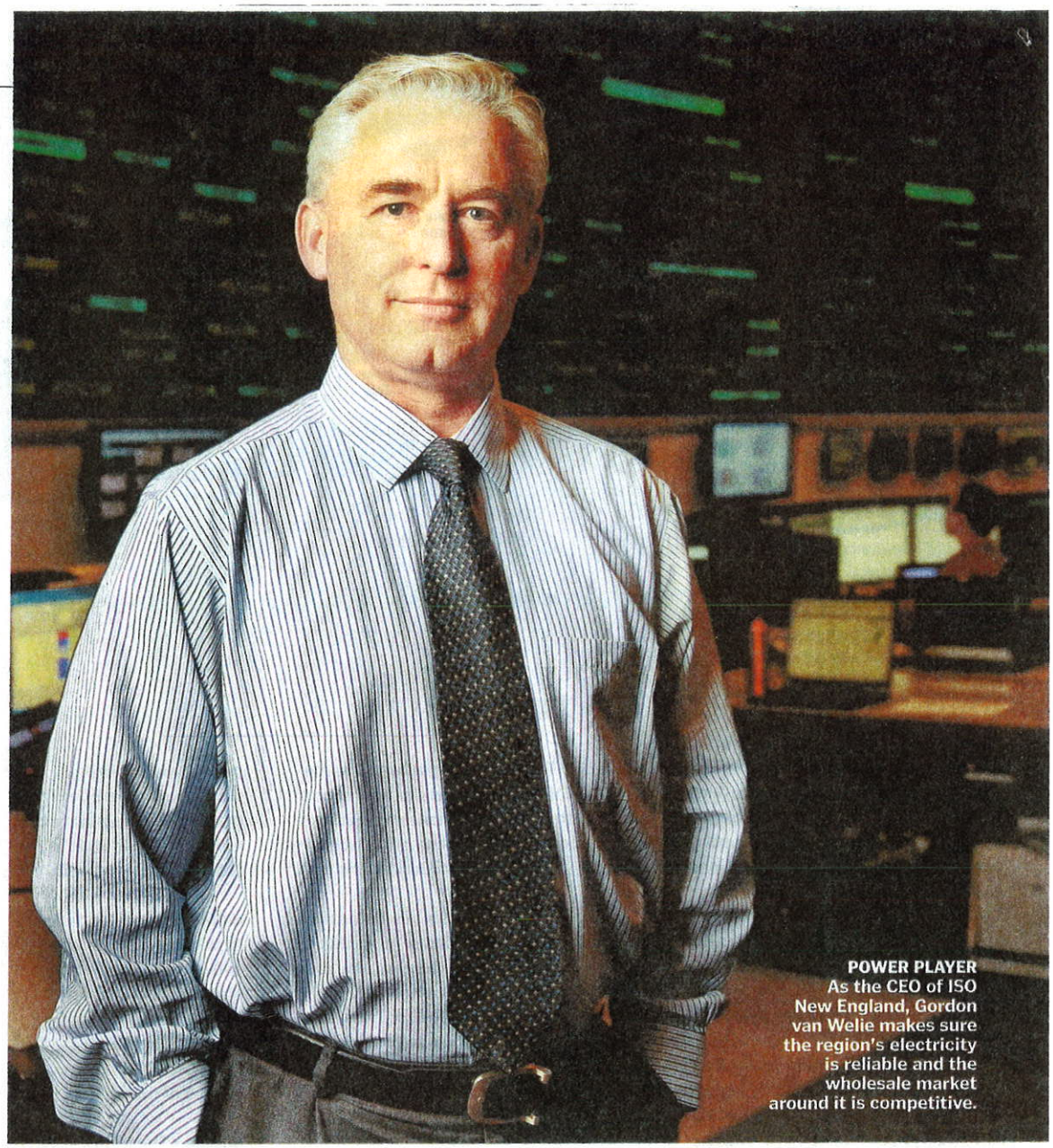
First-aid kit


Whistle to signal for help


Plastic sheeting for shelter, plus garbage bags

If our society is more reliant on power than at any time in history – without it, we've got no commerce, no communications, no clean water – and if power becomes less reliable in the future, the big question is: Will we be able to hack it?

The signs are not encouraging. The great blackout of 2003 – which left millions without power for between a few hours and a few days – cost the economy up to $10 billion. And think of how much more immobilized we'd all be if a similar blackout happened today. Back in 2003, people still carried around cash.



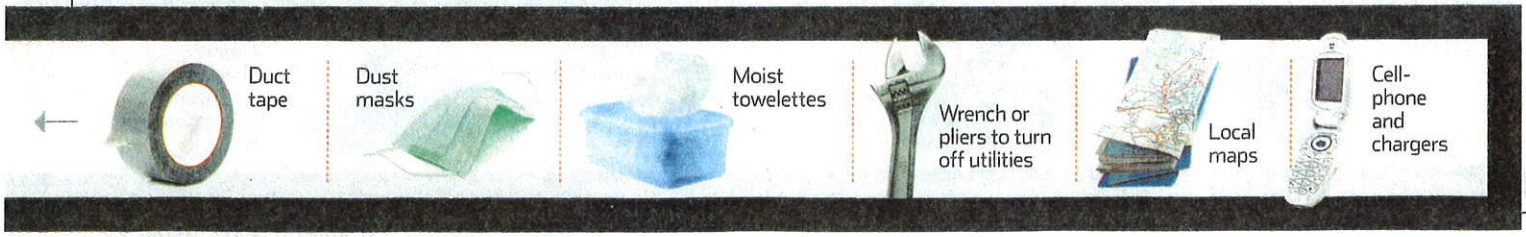
POWER PLAYER As the CEO of ISO New England, Gordon van Welie makes sure the region's electricity is reliable and the wholesale market around it is competitive.

The trouble with the future of power isn't that there is one big problem that could croak us. It's that there are a host of them, any one of which could croak us. Let's group them into three categories.

Bucket No. 1 involves what the insurance-policy fine print calls "Acts of God." Here we're talking about all those "storms of the century" that seem to be arriving with unsettling frequency. Although people can debate the reasons behind it, by now the trend is clear, says Tierney, a partner with Boston-based Analysis Group. "Extreme weather events will be more common." In fact, the government recorded more extreme-weather disasters in the United States in 2011 alone than it did in all of the 1980s combined. And as the Halloween storm showed, even people in neighborhoods with underground power lines won't necessarily escape outages, because those lines are fed somewhere along the route by aboveground equipment.

What's more, Mother Nature can hit us with a lot more than just high winds and heavy snow. Consider the solar storm. Magnetic activity of the sun can cause severe disturbances in the upper atmosphere that can seriously damage our electrical grid, corrode oil and gas pipelines, and mess with high-frequency radio communications and GPS satellites. This isn't some science-fiction plotline. It took just 90 seconds for a 1989 solar storm to cause the collapse of the Hydro-Quebec power grid, leaving 6 million Canadians without power for up to nine hours. A 2008 NASA-funded report noted the risk of significant damage to our interconnected grid in light of the forecast for increased solar activity. The 11-year solar cycle is expected to peak in 2013, and just two weeks ago we saw one of the biggest solar-radiation storms in years. Although that event left us unharmed, one model predicts that if we suffer a solar storm similar in intensity to one back in 1921, which was 10 times bigger than the 1989 Canadian storm, more than 130 million people could be left in the dark.

Let's call Bucket No. 2 "Acts of Terrorists."



VAN WELIE PHOTOGRAPH BY ALEX GAGNE

NATURAL-GAS DEPENDENCY IS A NATIONAL PROBLEM, SAYS ISO NEW ENGLAND'S GORDON VAN WELIE. "WE'RE THE CANARY IN THE COAL MINE."

Among these, there's the old-fashioned physical attack on the bulk power system, either at its source of generation or somewhere along its transmission route. There's the newfangled cyber attack on the computers controlling our interconnected grid. And then there's the otherworldly-sounding attack by an electromagnetic pulse, or EMP, weapon.

EMP attacks are meant to inflict the most lasting damage, using primarily high-frequency signals to fry electronic circuits in everything from traffic lights to X-ray machines to military warheads. The worst kind of EMP attack would be delivered by a nuclear weapon. Although there are other means of delivery, detonating a nuclear device in a central, grid-strategic location – say, above Kansas – could incapacitate electronic systems across the country.

A few months back, I made the mistake of falling asleep with the television on, tuned to C-Span. While a torpid House hearing on finance lulled me to sleep, sometime during my REM rebound I found myself in the middle of a *Day After*-style nightmare. Turns out, I was emerging from my slumber during a forum dominated by EMPact America, a well-funded advocacy group spreading the word about the looming threats of an EMP attack.

These guys know how to scare the daylights out of you. The most prominent EMP hawk is Newt Gingrich, who peppered some of last year's presidential debates with mini-lectures about the threat. "Without adequate preparation," Gingrich said at one EMP conference, "we would basically lose our civilization in a matter of seconds." There is real science behind the EMP fears, though some energy and national security analysts contend the EMP lobby greatly exaggerates the threat.

Analyst Sue Tierney is far more concerned about cyber threats. No bomb needed – just serious hacking qualifications, and these days it seems everybody knows a gloomy 17-year-old who's got those. In what is widely believed to have been an Israeli-American covert effort, the Stuxnet computer worm was unleashed on the Iranian nuclear program in 2010, ruining about a fifth of the centrifuges the country uses to enrich uranium. It would be naive to think our country won't eventually find itself on the other side of a similar attack.

Several years ago, Tierney was part of a National Academies task force charged with identifying the grid's vulnerability to terrorists. With the World Trade Center in mind, the task force largely concentrated on trying to anticipate another Al Qaeda-style conventional attack. If Tierney were serving on the task force right now, she says, she would push for even more focus on guarding against cyber threats.

But the chairman of the task force, Granger Morgan, says that what continues to worry him the most is the havoc that bad guys could cause with relatively little technological savvy. "If I'm a terrorist, I can shut down the power system in a lot simpler ways than using a valuable nuclear device," says Morgan, an engineering professor at Carnegie Mellon University and a noted authority on the grid. "All I need to do is destroy a bunch of major substations." Despite all the talk about strengthening security after 9/11, he says, "big transformers continue to sit there on pads out in the open, with only chain-link fences around them."

Any way you look at it, these are real threats that need to be treated seriously. Don't take my word for it. After Morgan's task force finalized its report, the US Department of Homeland Security swooped in and classified the document. Federal officials didn't want to give the terrorists any ideas. Not that they need any. Morgan says the task force used only publicly available material, much of which could be obtained by some savvy Google searches.

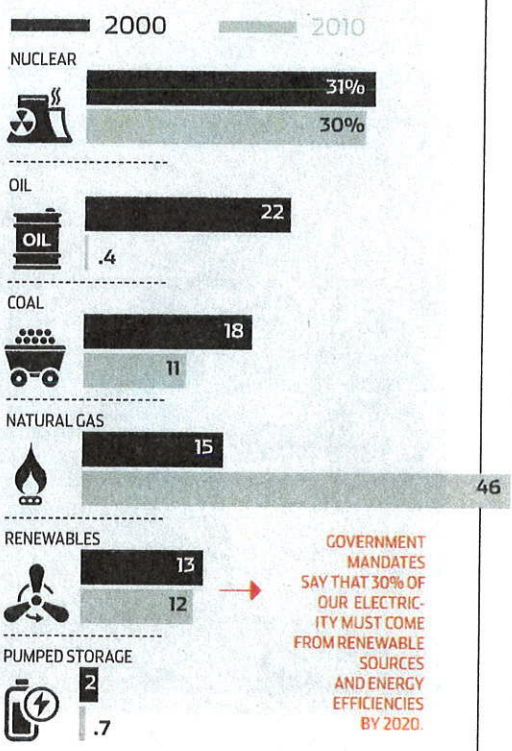
Finally, Bucket No. 3 is the "Ailing Grid" itself. In many places, the infrastructure is as old and stooped as a pensioner. As it is upgraded and its capacity is expanded, our rapacious need for more electrical power races to max it out once again. Many of the new sources of power that were promised as solutions for tomorrow – think nuclear – now seem dated and misguided. Who's going to greenlight a new nuclear power plant around here after what happened in Japan? As it is, there are mounting questions about the future of nuclear power plants in Massachusetts and Vermont, and New York Governor Andrew Cuomo is pushing to close down that state's Indian Point nuclear plant, which helps light up Manhattan's skyscrapers. Indian Point's backers are pushing back, producing pamphlets that depict kids doing homework by candlelight – burn those pencils, baby – and moms preparing dinner while wearing headlamps.

Meanwhile, new EPA rules limiting mercury emissions will lead to the closure of many dirty coal-fired plants across the country – a net plus for the environment, though likely a net loss in terms of power generation. And this picking off of our energy options, one by one, gets at one additional vulnerability of our grid, which is surprising, since it is one born out of the best of intentions.

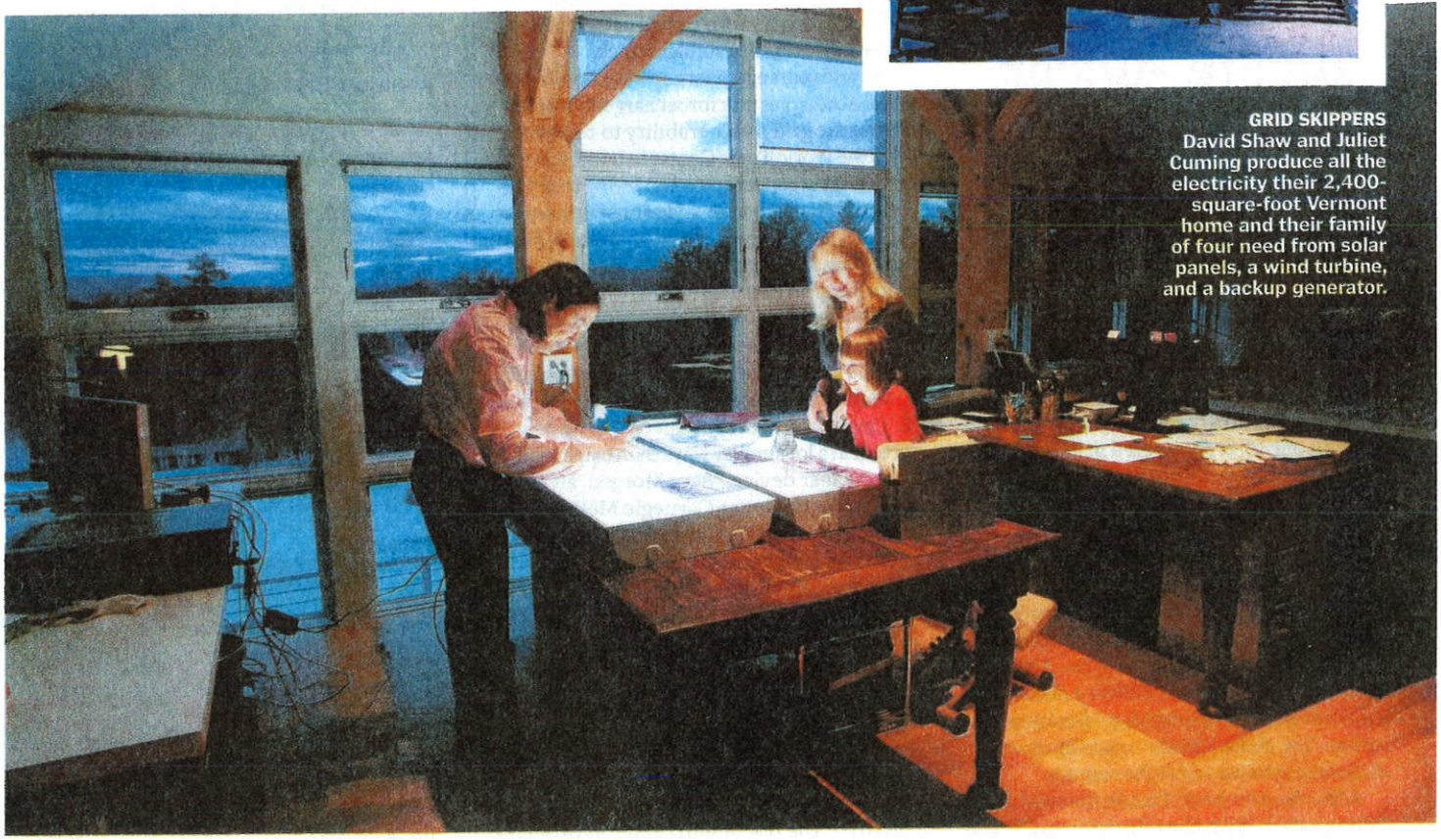
NEW ENGLAND'S WORRISOME ELECTRICITY EVOLUTION

Natural gas may be cheap and relatively clean, but analysts are concerned we're becoming too reliant on it, especially in the winter, when it is used both to generate electricity and heat homes. During January cold snaps in 2004 and 2011, the gas pipelines nearly maxed out, and the region scrambled to buy more power from oil-fired plants.

Where New England gets its power:



JULIET CUMING CAN'T UNDERSTAND WHY MORE PEOPLE DON'T LIVE OFF THE GRID. "WE HAVE A FABULOUS LIFE," SHE SAYS.



GRID SKIPPERS David Shaw and Juliet Cuming produce all the electricity their 2,400-square-foot Vermont home and their family of four need from solar panels, a wind turbine, and a backup generator.

The vanilla buildings off the highway in Holyoke could easily be mistaken for the home office of an insurance company – except no insurance company would neglect to post a sign out front. Yet this operation is meant to keep a low profile. Tucked inside is the highly sensitive nerve center for New England's electrical grid.

The nonprofit ISO New England is responsible for making sure our electricity supply remains reliable and the wholesale market around it remains competitive. Even more than the bucket-truck crews for NStar and National Grid, this is the gang that keeps our lights on.

ISO New England's control room is dominated by a dynamic display board, 12 feet tall and 48 feet wide. It shows exactly what is happening on New England's grid, which consists of some 350 plants generating electricity that is sent across 8,000 miles of high-voltage transmission lines to hundreds of substations dotting the six-state region. From there, the electricity is stepped down in voltage so it can feed the local distribution lines that National Grid, NStar, and other utilities use to power our iPhones, ATMs, and gas pumps.

With its labyrinth of lines connecting rectangular blocks, each signifying a major power plant or substation, the display board shows which generators are operating, how much they're producing, and which ones are deliberately offline or have essentially called in sick. At a half-dozen semicircular desks arranged in front of the display board sit operators – many of them ex-military and experienced in high-stress situations – who try to anticipate problems and pounce before a small disturbance turns into a big blackout.

In addition to offering a real-time picture of the bulk power supply, the display board hints at a little understood trend. A decade ago, 22 percent of New England's electrical power came from oil-fired plants and 15 percent came from natural gas-fired ones. Today, about half of our electrical power comes from natural gas, while a *fraction of 1 percent* comes from oil. And our reliance on natural gas promises to grow even more significantly in coming years. Why? With the dramatic reduction in the price of natural gas – thanks in part to the environmentally controversial "fracking" method of extracting shale gas buried under huge swaths of this country – oil-fired power plants have become uneconomical to operate, so they generally lie idle these days, used mostly in times of peak de-

PHOTOGRAPHS BY CALEB KENNA

mand or when natural gas plants go down. But it won't make financial sense for the owners of these oil and similarly old coal-fired plants to invest in the costly upgrades needed to keep them going if they can't hope to compete on price with gas-fired plants. As they are retired, most will be replaced with natural gas-fired plants, increasing our reliance that much more.

For the environment, this trend is a real improvement. Natural gas is far cleaner than oil or coal, producing half the carbon dioxide emissions of the latter. But for overall reliability of the power system, says ISO New England CEO Gordon van Welie, it is something altogether different.

Sitting at a conference table overlooking the control room, van Welie cuts a dignified yet friendly figure, with his white hair, easy laugh, and impeccable South African-inflected diction. Yet a grave look plays over his face when he says, "The issue that keeps us up at night here is the dependency on natural gas."

In parts of the country where coal is plentiful, like Wyoming and Kentucky, it remains the fossil fuel of choice. But New England long ago began its march away from coal and toward natural gas. "It's a national problem," van Welie says, before invoking a familiar metaphor. "It happens to be that we're the canary in the coal mine."

As soon as those words leave his mouth, the grave look shifts to the faces of the public relations staffers around him. "But this canary will survive!" one of them nervously interjects.

True, we don't have to worry about our lights going out with the frequency of a place like Lahore, Pakistan, whose 8 million inhabitants have been conditioned to accept spotty power. And there are promising potential solutions in renewable energy sources like wind and solar. Yet, some important limitations tend to get lost when people rhapsodize about renewables. Although wind and solar power represent a wonderfully clean source of electricity, in energy parlance, they are not particularly "dispatchable." If the weather doesn't cooperate, you can't meet increased demand by simply turning up the power spigot and having renewable energy flow out the tap. Also, wind and solar farms typically sit far from population centers. "How do you capture air or rays of sunshine and actually move it long distances?" van Welie asks. The answer: You need to build high-voltage transmission lines.

Add to that the push to move our petroleum-powered transportation system to electric and hybrid cars and trucks, and you see how our reliance on electricity in our digital world will keep ratcheting up. So we'll need more electricity, and until we figure out a way to make renewables a lot more reliable, we'll be much more dependent on natural gas to produce it.

What's the big worry? First, history tells us that as we continue to increase the demand for a particular energy source, we'll eventually drive the price way up. Second, the natural gas pipelines feeding this region were built to serve our heating – not our electrical needs. Most of the year, there's sufficient room in the pipeline to supply both. The danger zone, however, comes when the temperature plummets. During stretches of brutal cold, the pipeline capacity can be quickly used up by the natural gas needed to heat our homes and businesses. And unlike oil and coal, natural gas supplies cannot be easily stored in large quantities. (Liquefied natural gas – or LNG – presents cost and capacity issues.)

This is no theoretical concern. Van Welie points out that during January cold snaps in 2011 and especially in 2004, ISO New England came perilously close to having to institute rolling blackouts in order to prevent a massive one. If just one more significant power supply had experienced a failure during that 2004 deep freeze, he says, they would have had no choice but to begin turning off the lights. In both cases, ISO was able to avoid that fate by activating oil-fired plants, among other steps. But as those plants continue to go offline, where will our reserves come from? In periods of high demand, van Welie says, "we see glimpses of what the future might look like."

For a more encouraging glimpse into the future, head up to East Dummerston in southeastern Vermont. There, on 27 acres, Juliet Cuming and David Shaw live with their two children in a beautiful 2,400-square-foot house and run a photo-archive business in a building next door. Here's a partial list of what you'll find inside: flat-screen plasma TV, three laptop and two desktop computers, an Xbox, scanner, washer and dryer, dishwasher, toaster, and vacuum. Here's what you won't find: a bill from the electric company.

They have lived fully off the grid for 16 years now, producing all the energy they consume, relying largely on a wind turbine and a bunch of solar panels. They estimate that it cost them an extra $20,000 to have their home built so it could be a self-sufficient island of energy, and figure they have already recouped that investment.

"Juliet and I both grew up in New York City," Shaw says. "When you turned on a light, you flipped a switch, but you had no idea where the power came from." Today, they're acutely aware of how much power they are using at any time. After several days of gray and calm weather, when the turbine and solar panels produce precious little power, they turn to a propane backup generator. But, Cuming explains, "it's loud, so there's an immediate impact," like a dad bellowing at his kids to turn off the lights when they leave the room.

The only time a grid disturbance affects the couple directly is when storms fell power lines, and only then because Shaw is a volunteer firefighter charged with baby-sitting those downed lines until a utility crew arrives. When friends and neighbors find themselves without power, they often head to Cuming and Shaw's house.

"We have a fabulous life," Cuming says. "It's completely insane that more people don't live off the grid."

Unless the rest of us follow their lead and work to produce more of our own power, we'll have to make do, hoping the juice stays on, and when it doesn't, hoping we'll be able to cope. But how will we fare? We'd all like to think that if we were aboard an airplane headed for a certain crash, we'd be that brave passenger who calmly pens a love letter to his wife and slips it into his pocket. But how do we know we wouldn't be like the rest of the mob, trampling over grandmothers to grab one of the few working oxygen masks?

My sister told me about how, after the Halloween storm hit and people were fleeing her darkened Western Massachusetts town, she was with her three kids and stuck in traffic. Then, the guy behind her barreled onto the sidewalk in his car and raced to the Mobil station, to secure what he somehow convinced himself would be the last drop of fuel.

Farther south in Connecticut, Bill Ellis endured without power for nearly a week after Halloween. "I was amazed," the 71-year-old says, "at how uncomfortable and how irritated I was. I didn't have the pioneer spirit I thought I had."

Ellis says he always thought his upbringing in rough-and-rural Louisiana, where violent thunderstorms regularly knocked out power, would have conditioned him to withstand even a long outage. Yet he was shocked at the reality of trying to live a modern life without power and how quickly the world changes when you're forced to go without it for days.

Here's something else to note about Ellis: He's the retired CEO of Northeast Utilities, one of the largest electrical and natural gas distributors in New England. ■

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